Fire dampers must be qualified for closure under airflow by testing in accordance with AMCA 500-D[24] for both plenum-mounted and duct-mounted configurations. The damper must close completely at maximum airflow rate for various sizes of dampers and for maximum static pressure. Fire and smoke dampers must be tested in accordance with UL-555[70] and UL-555S,[71] respectively, when dampers are required in fire- or smoke-rated barriers.

5.3.5 LOUVERS

The function of louvers is to keep rain, snow, and trash from being drawn into outside air intakes for air handling systems. They can be either fixed-blade or movable-blade design. The vast majority of louvers are of the fixed-blade type. If shutoff or modulation of the air stream is necessary, dampers can be used downstream of the louvers. If operable louvers are used and shutoff or modulation is required, then an operator is required (see Section 5.3.2). Architects usually are consulted when specifying louvers because the louvers are located on outside walls or roofs and should blend in with the architectural features of the structure.

It is important to account for the amount of area that the louver blades take up when sizing the louvers. Blades typically take up 50 percent or more of the free area that affects the velocity of the air entering the intake. The usual maximum velocity to prevent water and snow entrainment in the air stream is less than 500 fpm. Therefore, if 1000 cfm of air is being drawn into an intake and the louvers take up 50 percent of the free area, then the square footage of the opening required is:

1000 ft^3/min x 1/500 ft/min x 1/50 percent = 4.0 ft^2 opening required

In addition to the free area and velocity considerations, the pressure drop of the intake louvers must be included in the system pressure drop calculations.

For louvers on exhaust openings, the velocity is not usually a primary concern, with the exception that the higher the velocity, the higher the pressure drop that has to be accounted for in the system pressure drop calculations.

Finally, louvers must meet the same structural requirements as the rest of the air cleaning system. That is, they must meet the seismic loading requirements if they are required to function during and after a DBA.

Louver testing must conform to AMCA 500-L[43]

5.4 FANS AND MOTORS

The selection of fans and motors for air treatment systems is a very important part of the design of the systems. An air cleaning unit may be properly designed and arranged, the duct system may be nearly leak-free, dampers may be properly constructed, and controls may be functioning correctly, but if the fan is not sized and selected properly, then the system will not perform its design function. For example, the system resistance must be correctly calculated, the effect of parallel or series fans must not result in surging, and the fan must be selected for the applicable range of airflow and pressure. ASME AG-1, Article BA-4110,[63] contains a list of the design parameters necessary to properly specify and/or select a fan and motor.

This section will review the types of fans commonly used in air cleaning systems, guidance on proper fan sizing, fan arrangement, connection to duct systems, leakage, mounting, and qualification testing. All of these factors must be considered when designing, selecting, and installing these fans.

5.4.1 FAN TYPES AND APPLICATIONS

Fan types can be classified as centrifugal, Vaneaxial, and high-pressure blowers. Centrifugal fans can be further classified by blade type as airfoil, forward curve, radial, and backward inclined/backward curved. Vaneaxial fans can be classified as either fixed or adjustable pitch. Typical fan curves for each of these fan/blade types are shown in **FIGURE 5.10**. All fans can be furnished as either direct or belt drive. Note that, for nuclear power plant applications, fans located inside the containment are usually direct drive to minimize the maintenance and adjustments associated with belt drives (because containment entry is limited).

Many nuclear cleaning systems differ from conventional HVAC systems in that they usually are high-pressure systems (greater than 10 in.) and could be low-flow (3,000 cfm) or high-flow

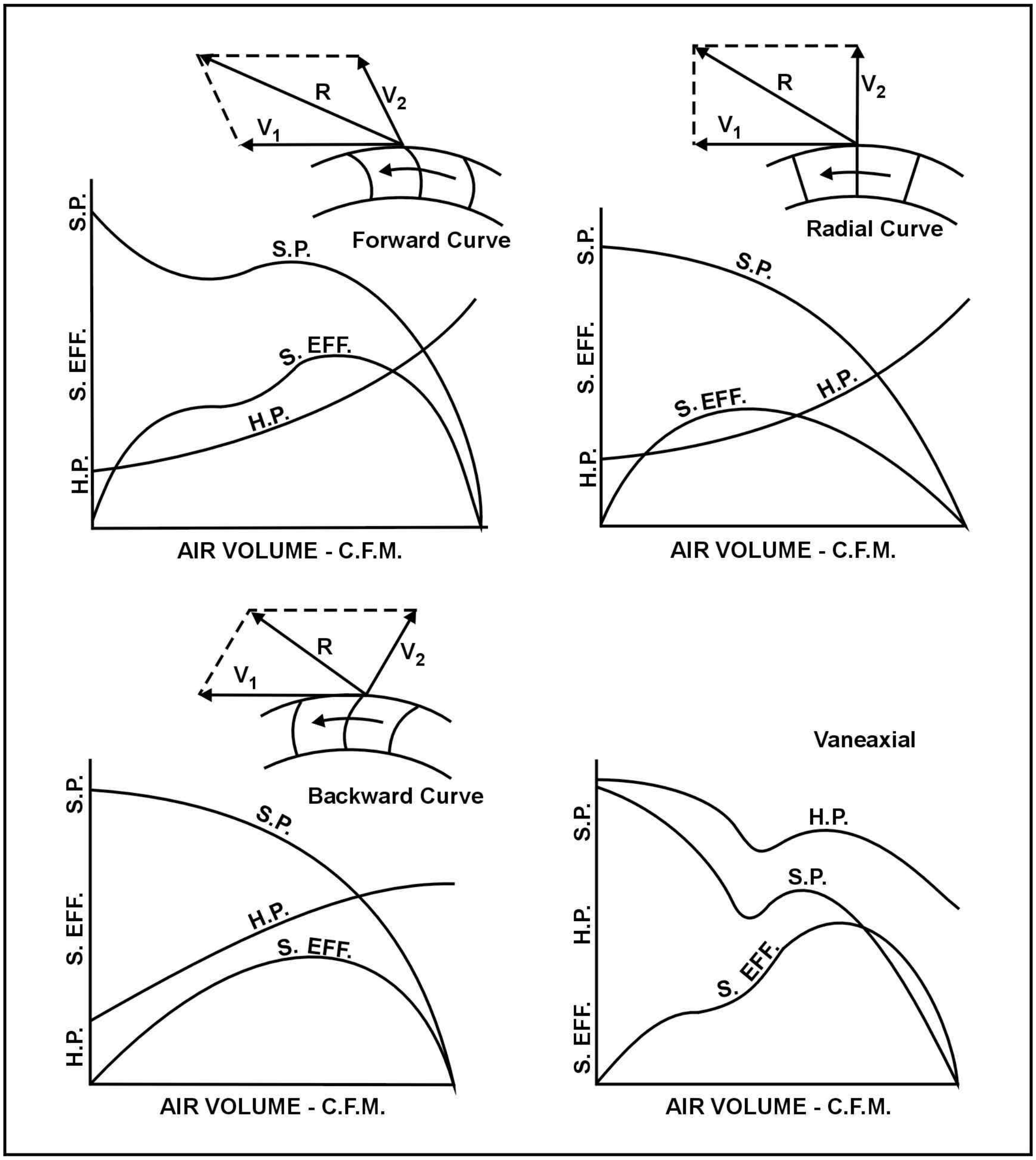


Figure 5.10 – Typical fan curves

(greater than 100,000 cfm). In addition, the system design pressure could fluctuate by 2.5 to 3.5 in.wg, depending on the number of banks of HEPA filters in a system and the pressure at which the prefilters and HEPA filters are changed out. Typically, HEPA filters have a resistance of 1 or 1.3 in.wg, depending on size and airflow rating, when clean and could be changed out at 2 to 4 in.wg for each bank. Furthermore, Plant Technical Specifications for most systems require the airflow rate to be within +10 percent of design throughout the system operating pressure range. This means either flow control devices (such as modulating dampers) will be used and/or the fan characteristic curve will be so steep that fan airflow will not change by more than 10 percent as the system resistance changes. Typically, unless the pressure difference is not that great, the airflow change will exceed 10 percent. Therefore, flow control is required (see Section 5.6.2).

High-pressure blowers may be required when low airflow rates are low (10,000 cfm or less) and pressure extremely high (20 in.wg). An example of this may be the containment normal purge exhaust fans where the containment penetrations are limited in size.

The control room emergency make-up air cleaning system, on the other hand, may be less than 6,000 cfm (usually 2,000 cfm) with a system pressure in the range of 10 to 15 in.wg. This usually dictates a radial-bladed centrifugal fan selection.

Vaneaxial fans are typically used in larger built-up systems when the fan is located as part of the duct system rather than part of the filter housing. Vaneaxial fans are best suited for airflow rates greater than 30,000 cfm and pressures less than 10 in.wg (see **FIGURE 5.11**). Whenever possible, Vaneaxial fans should be located downstream of filter units because the fan motor is in the air stream. Vaneaxial fans are also used in power plant containment cooling systems (both draw through and blow through designs).

Fans should be selected such that fan power requirements are nonoverloading (i.e., the fan bhp does not increase with increasing airflow) unless provisions are made to prevent overloading the motor (e.g., airflow control and high limit trip). Radial-bladed and forward-curved centrifugal fan power increases with increasing airflow. With backward-curved centrifugal fans, as well as Vaneaxial fans, power curves decrease after peak efficiency, as shown in FIGURE 5.10.

Belt drives should be used only in areas that are accessible for maintenance during normal and accident conditions. Multiple belts should be provided so that loss of one belt does not impair system function. Variable pitch sheaves should be changed to fixed pitch sheaves after air balancing. Belt drive fans that must operate during and after dynamic events (e.g., seismic events) should be qualified for operation by testing.

Fans for general HVAC duty (e.g., air supply systems and small exhaust systems), are selected using the guidance for such systems that is found

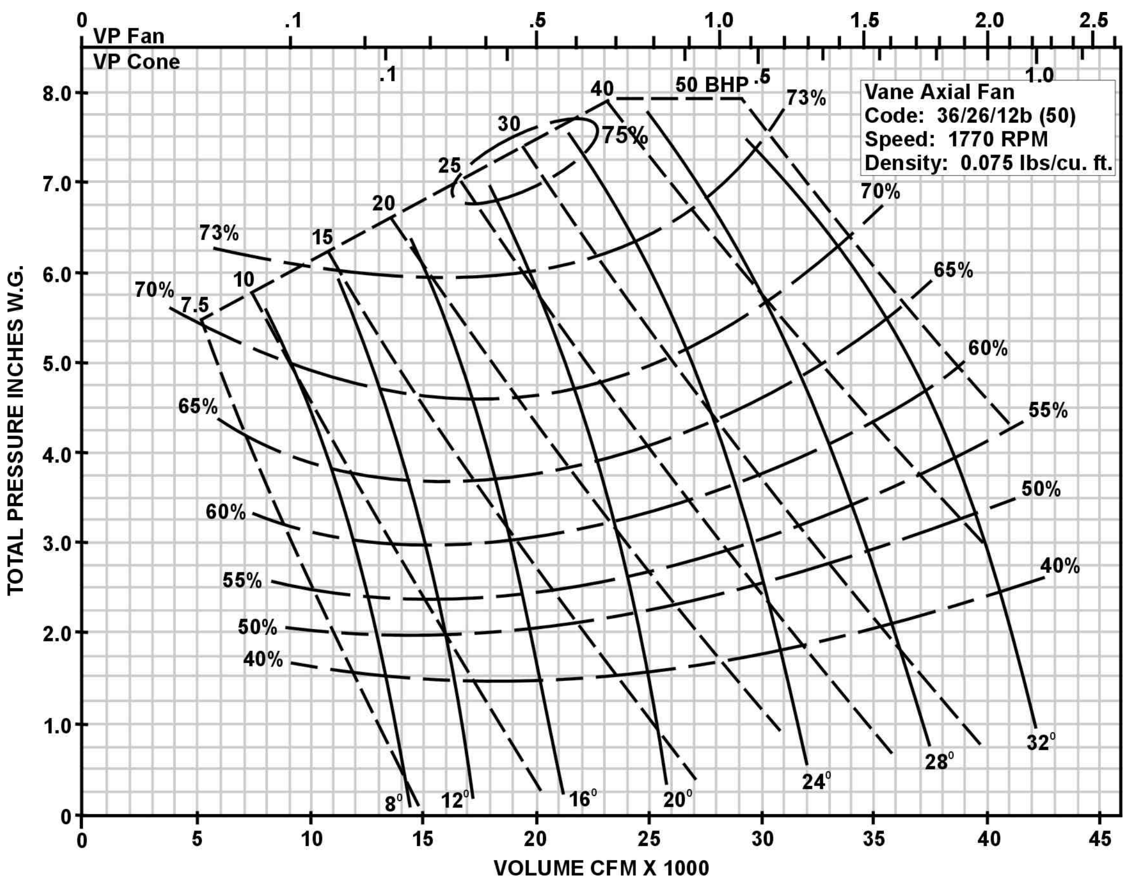


Figure 5.11

in sources as the *ASHRAE HVAC Applications Handbook*,[30] the *ASHRAE Systems and Equipment Handbook*, Chapter 18, "Fans,"[1] or *Fan Engineering*.[71] These systems can range in size from a few hundred cfm to over 100,000 cfm, and are usually low-pressure systems (less than 5 in.wg).

5.4.2 FAN PERFORMANCE

5.4.2.1 FAN SIZING

Pressure Drop Determination

Much has been done in the HVAC industry to improve the analysis of system resistance. The *ASHRAE Handbook of Fundamentals*[2] has expanded what used to be one table of fitting loss coefficients to more than 30 pages of fitting data. ASHRAE discusses methods for designing industrial exhaust systems and balancing branch duct resistance either by utilizing balancing dampers or by sizing ductwork. For systems handling highly radioactive particulate, self-balancing is recommended to eliminate particulate accumulation in the duct system. This recommendation must be considered against the potential for changes to duct runs during installation.

Use of the calculation method presented in the *ASHRAE Handbook of Fundamentals*, Chapter 34,[2] is recommended to determine fan pressure requirements. Acceptable methods are equal friction, static regain, and T-Method optimization. A total pressure grade line, summarizing the branch and main duct pressure drop, should be prepared for each fan system to analyze the system total pressure at various points. This grade line is also useful for reviewing or establishing the duct design (static) pressure (total pressure – velocity pressure in duct fitting).

If the fitting design does not match one of those in Chapter 34 of the *ASHRAE Handbook of Fundamentals*,[2] another useful reference is the ASHRAE Duct Fitting Database.[73] This is an interactive computer file on a 3.5 in. diskette containing loss coefficient tables for 228 fittings.

Sufficient margin should be included to cover the potential field modifications that may be necessary during initial installation, as well as any modifications that may be necessary throughout the life of the facility (see the following section on System Effect Factors).

Equipment (coils, dampers, filters, air diffusion equipment, etc.) resistance must be included in the pressure drop calculations. Whenever possible, calculations should be based on actual purchased equipment and, where possible, tested components. Preliminary calculations should be prepared with estimated pressure drop values and updated with final values.

AMCA 201[25] shows the effects of incorrect system pressure requirements compared to calculated pressure (see **FIGURE 5.12**).

System Effect Factors

The inability of fans to perform in the field in accordance with published ratings has long troubled the industry. This problem arises partly because the ratings are based on idealized laboratory conditions that are rarely encountered in the field, and partly because of design and/or field compromises that are made to accommodate the field situation. Many fan operation problems stem from poorly designed connections to the duct. Close-coupling, "too short" transitions between unmatched (in size) duct and fan inlets, square-to-round connections, and poorly designed inlet boxes create a vertical or eccentric flow into the fan impeller, resulting in noise, vibration, and reduced efficiency. A 45-degree spin in the direction opposite fan rotation may reduce fan delivery by as much as 25 percent and require a compensating increase in fan pressure of 50 to 55 percent. **FIGURE 5.13** (AMCA Figure 29) shows the effects of various inlet conditions on fan performance and the resulting increase in fan capability (fan static pressure) to compensate for these effects. Too often, these effects are not considered when calculating fan requirements, with the result that neither the fan nor the filters can perform to the desired design levels. Outlet connections also affect fan performance, as indicated in **FIGURE 5.14.**

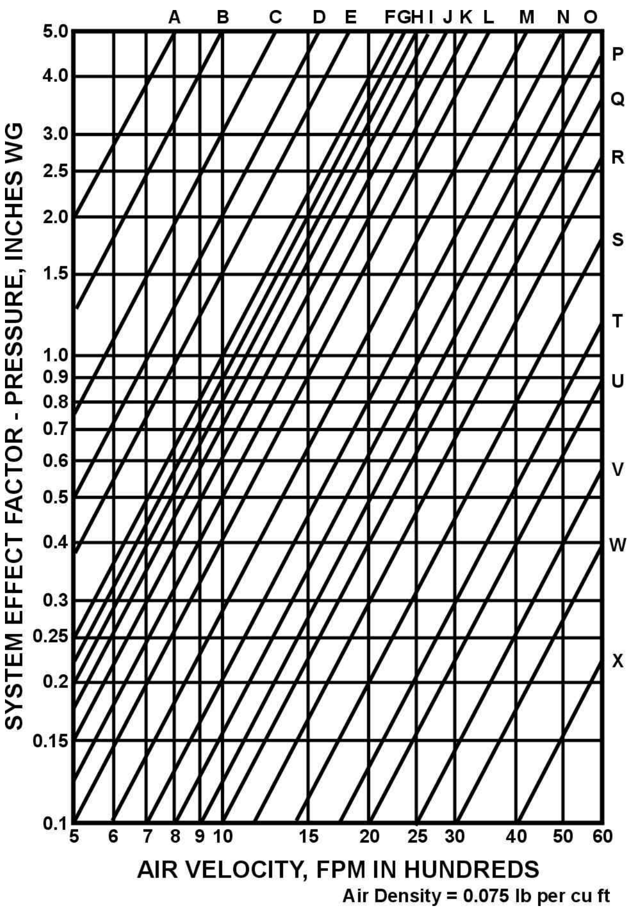
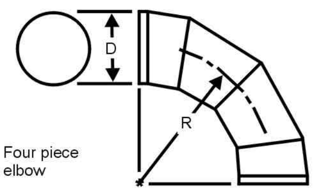
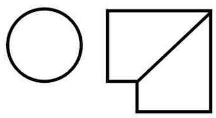
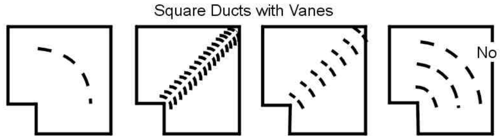
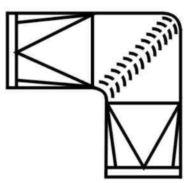
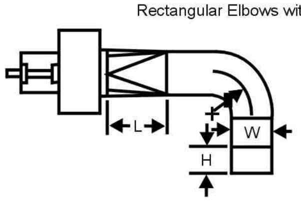
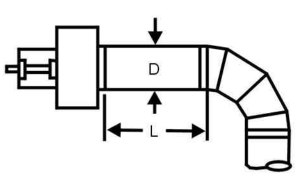


Figure 5.12 – System effect curves

To alleviate the situation, AMCA has published a *Fan Application Manual*,[25] Part 2 of which includes a set of "system effect curves" which the designer can use to predict the effects of design features (such as the inlet and outlet conditions illustrated in FIGURES 5.14 and 5.15) on fan performance and, when needed, to allow for them in initial fan selection. System effects are the losses in fan performance that result from the fan being installed in a less than ideal configuration. These effects must be considered by the designer to obtain a realistic estimate of fan performance under "real life" conditions. **FIGURE 5.16** illustrates a deficient fan–system interaction resulting from one or more undesirable design conditions. It is assumed that pressure losses in the duct system were accurately estimated (point 1, curve A), and a suitable fan, based on published ratings, was selected for operation at that point. However, no allowance was made for the effect of the fan connections on fan performance; (i.e., the interaction between the fan and the system as designed). To compensate for the system effect (capacity loss resulting from unfavorable interaction between the fan and its connections), a system effect factor must be added to the calculated system pressure losses to determine the actual system characteristic curve. It will then be possible to select the fan required to produce the required operating characteristics.

Testing to establish the capability of the fan in a nuclear air cleaning system, as originally installed, is recommended by ANSI N510[18] and ASME AG-1, Section TA.[63] Part 4 of the AMCA *Fan Application Manual*[26] provides guidelines for such testing, including examples of the application of system effect factors for various system configurations. Planes of measurement, measurements to be made, average test readings, calculation of test results, and corrections to overcome deficiencies disclosed by the tests are all covered in detail. It is preferable to apply such system effect factors before selection, purchase, and installation of a fan to prevent the incorporation of unfavorable features into the system design. In applying system effect factors, it must be recognized that those factors given in the AMCA manual are only guidelines and general approximations, although many have been obtained from research studies. Fans of different types and fans of the same type that are made by different manufacturers will not necessarily interact with the system in exactly the same way. It is necessary, therefore, to apply judgment based on experience using system effect factors. The appendices to Part 4 of the AMCA *Fan Application Manual* (AMCA 203[26]) provide the background for such judgment factors.

DESCRIPTION	PERCENT LOSS IN CFM IF NOT CORRECTED	PERCENT INCRESE NEEDED IN FAN SP TO COMPENSATE
Four piece elbow Three piece elbow R/D = 0.5 1.0 2.0 6.0	12 6 5 5	30 13 11 11
Four piece elbow R/D = 1.0 2.0 8.0	6 4 4	13 9 9
Five piece elbow R/D = 1.0 2.0 8.0	5 4 4	11 9 9
Mitered elbow	16	42
Square Ducts with Vanes A B C D No Vanes A B C D	17 8 6 5 4	45 18 13 11 9
Round to Square to Round	8	18
Rectangular Elbows without Vaines* In all cases use of three long, equally spaced vanes will reduce loss and needed sp increase to 1/3 the values for unvaned elbows. $\frac{H}{W}$ - 0.25, and $\frac{R}{W}$ = 0.5 1.0 2.0	7 4 4	15 9 9
The maximum included angle of any element of the transition should never exceed 30°. If it does, additional losses will occur. If angle is less than 30° and L is not longer than the fan inlet diameter, the effect of the transition may be ignored. If it is longer, it will be beneficial because the elbow will be farther from the fan. $\frac{H}{W}$ - 1.00, and $\frac{R}{W}$ = 0.5 1.0 2.0	12 5 4	30 11 9
$\frac{H}{W}$ - 4.00, and $\frac{R}{W}$ = 0.6 1.0 2.0	15 8 4	39 18 9



Each 2 1/2 diameters of straight duct between fan and elbow or inlet box will reduce the adverse effect approximately 20%. For example, if an elbow that would cause a loss of 10% in CFM or an increase of 23% in fan SP, if on the fan inlet, is separated from the fan by straight duct, the effect of the duct may be tabulated thus:

No duct	Loss = 10%	SP needed = 23%
L D = 2 1/2	Loss = 8%	SP needed = 19%
5	Loss = 6%	SP needed = 13%
7 1/2	Loss = 4%	SP needed = 9%
10	Loss = 2%	SP needed = 4%

Figure 5.13 – Effect of fan inlet on fan performance

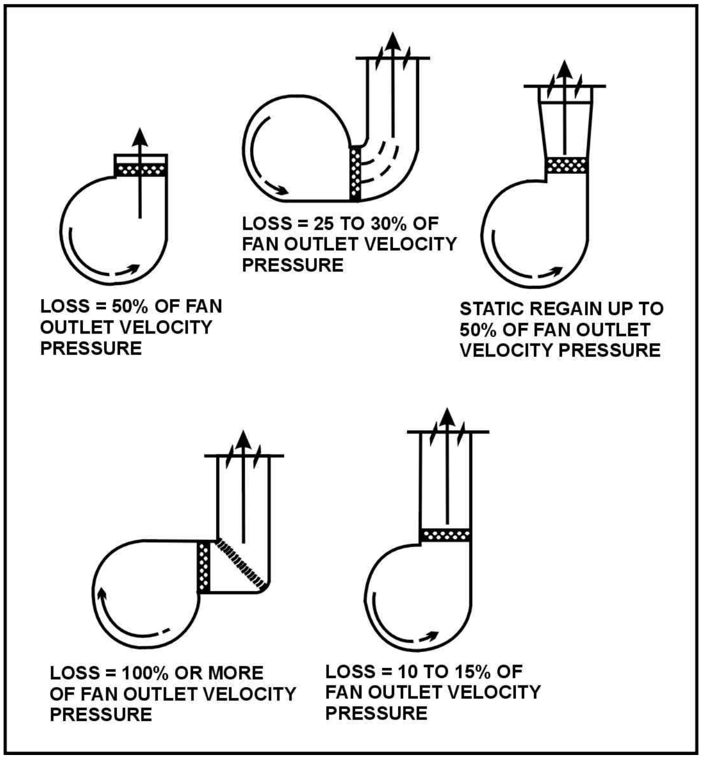
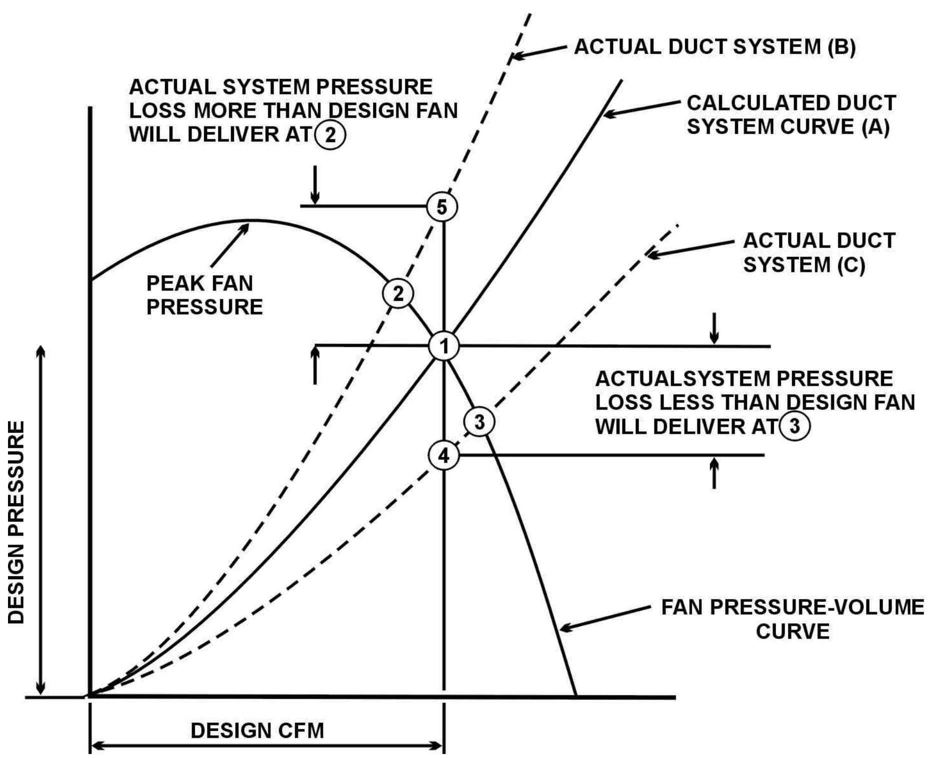


Figure 5.14 – Effect of fan outlet connection on fan performance



5.4.2.2 FAN AND SYSTEM CURVES

A major requirement for a fan operating in a high-efficiency air cleaning system is its ability to perform safely and efficiently over a much larger variation of resistance than more conventional ventilation systems. This variation of resistance is caused by dust loading of the HEPA filters and may double from the time of filter installation to the time of filter change, or may increase as much as five times in some systems (see the discussion of particulate filter change frequency in Section 2.6.7). The increase in resistance across the HEPA filters is usually the major factor influencing the pressure flow relationships (represented by the numbered curves in FIGURE 5.12) of high-efficiency air cleaning systems. Fan performance (airflow versus pressure capability) and system resistance versus airflow are represented by characteristic curves such as curves A, 1, and 2 of FIGURE 5.12. The volume of air that can be delivered by the fan is determined by the intersection of the fan and system characteristic curves. The flow represented by this point of intersection is the only flow that can be delivered by the fan under the given operating conditions. In most cases, a fan with a steeply rising characteristic (curve A, FIGURE 5.12) is desirable to maintain reasonably constant airflow in the system over the entire life of the HEPA filters. If a fan with a broad, flat characteristic is chosen, it will be less capable of delivering the required airflow as the filters become dust-loaded (curve 1 to curve 2), and either system performance (i.e., airflow) or filter life will have to be sacrificed. Any decrease in filter life will, of course, be accompanied by higher change frequency and corresponding increases in operating and maintenance costs. If a pressure-equalizing device (damper) is installed to balance system pressure against filter pressure drop in order to maintain a constant pressure-airflow relationship in the system, a penalty in operating (power) costs will result.

5.4.2.3 FAN LEAKAGE

Flexible Connection Leakage

Vibration created by fans, motors, and drives can be isolated by using flexible connections between the fan and ductwork on both the fan discharge and suction. Where such connections are used, a frequent problem has been tearing and pulling-out of the fabric (from which the flexible connection is made) at the connector clamp and an associated increase in leakage. The flexible connection design shown in **FIGURE 5.16** can overcome these problems. The fabric shown consists of two layers of 30-oz neoprene-impregnated fiberglass cloth, lapped so that the ends are displaced from one another, and glued. Flexible materials reinforced with fiberglass or other products are also available. Flexible connections should be periodically inspected (visually) to ensure the connection is intact (no tears or holes). Eliminating leakage at the flexible connection is important to the effective operation of the unit. With the fan located properly with respect to the contamination concentration, the leakage on the suction side should not impact personnel dose, but could impact system effectiveness by reducing the flow rate of the discharge leakage through the connection at the point of contamination. This could affect the local maximum permissible concentration (MPC) levels, depending on the relative concentration between the space and the duct.

Flexible connections should be qualified for the temperature, pressure, relative humidity, and contaminants that will be encountered (see TABLE 2.2). However, since the flexible

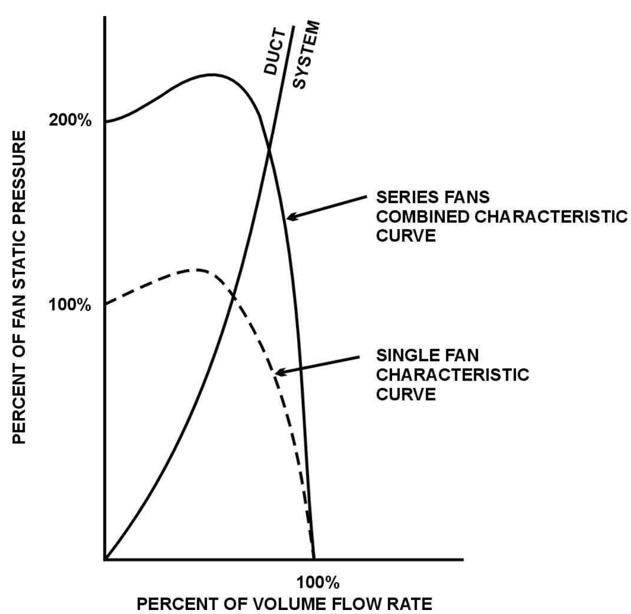


Figure 5.16 – Typical characteristic curve of two fans operating in series

connections are exposed to continuous stresses due to airflow turbulence and fan vibration, the flex connections should be replaced frequently throughout the life of the plant. A maintenance frequency should be planned based on the results of the periodic surveillance inspections for each specific fan.

Shaft Leakage

Fan shaft penetration of fan housings should be designed to minimize leakage. When the fan is located properly so that leakage does not impose a contamination burden on the space, or the fan is located in the space supplied by air from the fan, then no special sealing is required. However, if there is a potential for a significant increase of MPC levels or a significant impact on airflow rate from the space the air is being induced from, then shaft seals should be installed. Shaft seals should limit leakage to 0.01 percent of design airflow rate per inch of fan operating pressure or 0.5 cfm, whichever is greater.[63]

Fan Housing Package

Fan housings should be specified to be leaktight, including all penetrations and access doors. Access doors should be bolted and gasketed.

5.4.2.4 Fan Arrangement

Fan Location

The location of the fan in the system relative to the filter housing is an important consideration in minimizing the effect of system leakage. Fans in contaminated exhaust systems installed immediately downstream of the filter housing and as close to the stack as possible place most of the system under negative pressure. Leakage is into the system, thus ensuring greater personnel dose protection. In addition, the fan handles cleaner air, thus reducing maintenance personnel dose during fan repair or overhaul.

For habitability systems with the filter housing located outside the protected space, the fan should be located on the upstream side of the filters. This eliminates system in-leakage that could bypass the filters.

Fans have been located within the filter housing to reduce noise transmission and, more importantly, shaft leakage concerns. However, adequate space must be provided for air inlet conditions (refer to Figure 35A of AMCA Publication 201[25] and maintenance. Further information is covered in Section 5.4.2.3 "Fan Leakage."

Multiple Fan Installation

Installation of two fans in series is sometimes desirable where a steeply rising pressure-airflow characteristic is needed. However, caution must be exercised in such a design. In theory, the combined pressure-volume characteristic of two fans operating in series is obtained by adding the fan pressures at the same volumetric airflow, as shown in FIGURE 5.15. Care must be taken in designing the connection between the fans, because a significant loss of efficiency can occur in the second-stage fan due to nonuniform airflow into its inlet, particularly if the two fans are closely coupled. Manufacturers may be able to install two fan wheels in series within a single housing, which is longer than a single-wheel fan. Fan manufacturers should provide certified fan performance curves for these multistage fans.

For fans installed in series and not in a common plenum, a bypass duct is recommended so that a failed fan can be isolated from the system for repair and to avoid additional system resistance due to the failed fan wheel.

Two or more fans are often operated in parallel to move large volumes of air, to enhance the control of segmented air cleaning facilities, or to limit the installed capacity (i.e., filters, adsorbers) of any one unit of the air cleaning system. The combined volume-pressure curve in this case is obtained by adding the volumetric capacity of each fan at the same pressure (FIGURE 5.16)

One concern in parallel fan installations is that some fans have a positive slope in their characteristic curves to the left of the peak pressure point (FIGURE 5.16). If the fans are operated in the pressure-volume regime of this positive slope, unstable operation may result. This is shown by the closed loop to the left of the peak pressure point in FIGURE 5.16 (this loop is obtained by plotting all of the possible combinations of flow at each pressure). If the system's characteristic curve intersects the fan characteristic in the area of this loop, more than one point of operation is possible; this may cause one of the fans to handle more of the system airflow than the other and result in a motor overload. The unbalanced flow conditions tend to shift rapidly so that the fans intermittently load and unload. The pulsing that results from such loading and unloading generates noise and vibration and may cause damage to the fans, motors, and ductwork. In addition, if more than two fans are operated in parallel, the designer and/or fan manufacturer should review the fan performance curves and system curves for possible combinations of fans, assuming one or more are out of operation for maintenance, filter change-out, or repair. Fans should be selected for stable flow throughout the service conditions (clean to dirty filter pressure drop) and combinations of fans.

Mounting

Proper mounting of the fan will minimize noise and vibration and reduce maintenance costs. Noise is objectionable in supply and exhaust systems and is often difficult and costly to eliminate after the system goes into service. Excessive noise in exhausts and air cleanup systems is often accompanied by vibration and pulsation. These conditions may be harmful to filters, adsorbers, and other components. Flutter of HEPA filter separators, for example, is a common cause of filter failure, and vibration of activated-carbon-filled adsorbers can result in settling and crushing of the granules and, eventually, carbon loss that can cause bypassing of contaminated air.

When practicable, mounting of the fan and motor on a common base designed for isolation of vibration is recommended. **FIGURE 5.17** shows a typical base for large fans. The fan and motor are mounted on a concrete base that acts as an inertial pad to limit the amplitude of vibration and to dissipate vibrational energy. The pad is mounted on spring isolators, which will provide a high degree (99 percent or more) of vibrational damping. For some systems, positive amplitude limiters may be required to restrain the base from excessive movement under extreme conditions

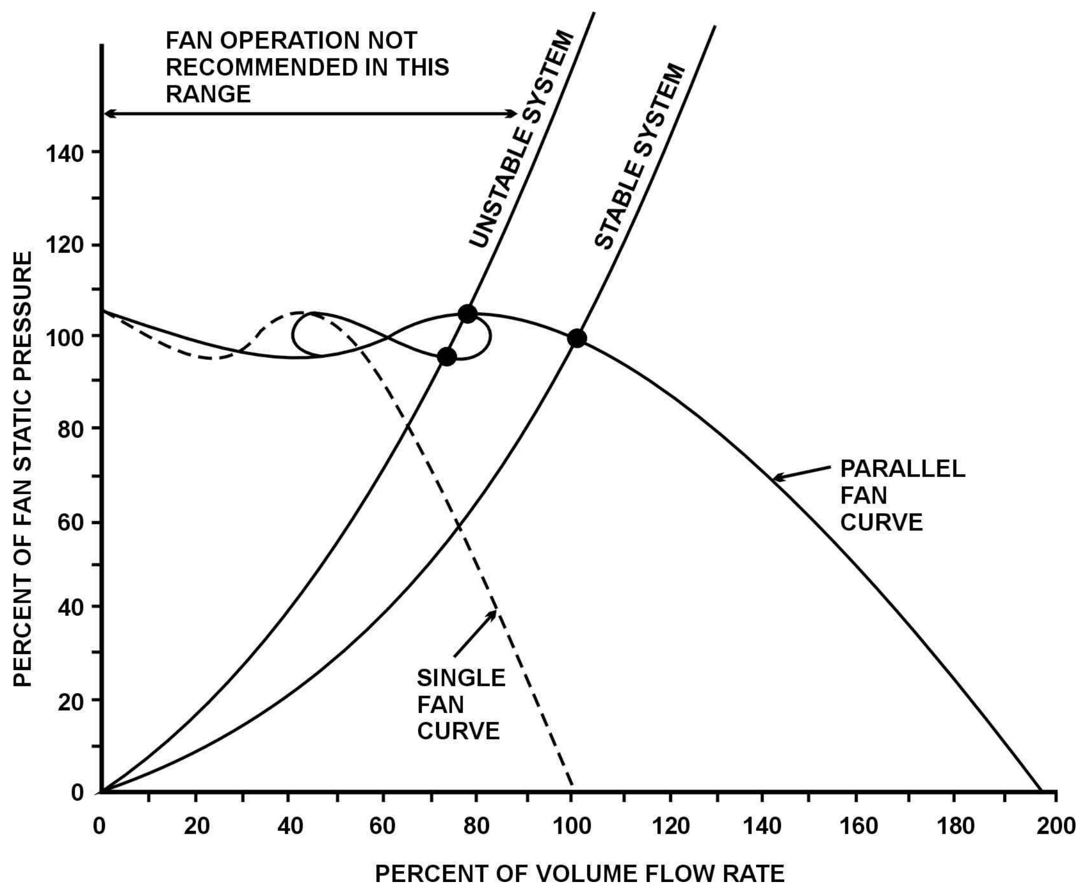


Figure 5.17 – Parallel fan operation

(such as the accelerations imposed by an SSE or DBA). Some designers require hard-mounting of fans where seismic requirements and continued operation during and after an earthquake must be considered. Careful balancing of the fan shaft and impeller to minimize vibrations that cannot be isolated via installation design is particularly important in this latter design.

Building Pressure Effects

Sizing of supply and exhaust fans must recognize the interaction of these fans with each other in order for nuclear air-cleaning systems to maintain proper space pressure relative to surrounding areas. See Section 2.4.2 for additional information concerning these interactions.

In push-pull systems (i.e., systems containing both supply and exhaust fans that operate at the same time), the space pressure depends on the relative capacity of the fans. If supply flow exceeds exhaust, the space is positive. If exhaust exceeds supply, the space pressure will be negative. When space pressure is required to be negative, the exhaust fan capacity should compensate for infiltration, pressure surges, wind effects (i.e., pressure variations in the building and ductwork due to variable wind conditions exterior to the building), as well as temperature variations between supply and exhaust air, to eliminate any possibility of overpressurizing the building via the supply fans. The pressure effects of other building ventilation systems serving adjacent spaces should also be considered.

Improper fan operation can be avoided by carefully evaluating system pressure drops and interactions under all predictable operating conditions, and by specifying the type and size of fan that matches the demands of the duct system as installed. Control must be exercised over the installation of ducts and fans to prevent field compromises that can reduce the ability of the system to perform as intended.

5.4.2.5 FAN CONSTRUCTION

The AMCA has developed standards for fan construction. In general, these standards are applicable to the construction of fans for nuclear air cleaning systems. In addition, fans for nuclear air cleaning systems should be constructed in accordance with ASME AG-1, Section BA,[63] which defines additional, specific features that are required for nuclear applications.

Fans for nuclear power plant post-accident cleanup systems require special consideration. If the fan and motors are located inside primary containment, they must be capable of operating continuously for long periods of time at both normal containment conditions and following a DBA or SSE. The DBA service environment can be extremely severe. To meet these conditions, fans and motors require special design, construction, and testing. The plant owner must obtain documented proof, based on reliable model or prototype testing, of their ability to perform under such conditions, including calculations and test data pertaining to all components. Acceptance tests are essential to verify that the equipment is capable of performing its design function. Regular and routine operational checks should be made in accordance with a preplanned schedule to verify the continued reliability of the system.

5.4.2.6 QUALIFICATION AND TESTING

Fans for nuclear air cleaning systems should be qualified, rated, and tested for the following:

- Performance
- Structural capability
- Vibration
- Sound
- Leakage
- Environmental conditions

ASME AG-1 Code, Article BA-5000,[63] provides inspection and testing requirements for fans and motors. AMCA 210[64] defines the methods for testing fans for rating purposes. Environmental qualification and testing of electrical components should be in accordance with IEEE-323.[73] Testing and calibration of portable radiation protection instruments should be in accordance with ANSI/IEEE N323A.[74]

Standard motor tests that include "First Unit of A Design" and "Routine Motor Tests" (all motors) should be performed in accordance with IEEE 112[75] and ASME AG-1, Article BA-5000.[63]

Documentation of test results should be prepared in accordance with the above references.

5.4.2.7 Fan Reliability and Maintenance

Operational reliability is an important consideration in selecting fans for nuclear applications. Even when the system is planned for part-time or intermittent operation, continuous operation may be required after the system goes into service. This should be a consideration in the design and procurement process.

Adequate access for maintenance and service is imperative, and fans installed above floor level must have sufficient clear space around and below for personnel to get to them with the aid of ladders and/or scaffolding. Permanently installed ladders and galleries are recommended to ensure ease of access for maintenance and repair.

Procedures should be developed for periodic, preventative maintenance based on the fan manufacturer's recommendations and actual field operational experience. These procedures are critical for the reliability of the fan and its operational readiness in the event of a DBA.

5.4.2.8 Special Duty Considerations

Temperature, Pressure and Humidity

Fans are constant-volume machines whose airflow rate can be impacted by variables such as temperature, pressure, and relative humidity because they affect the pounds of air being moved. It is necessary to identify and specify these variables for both for normal and accident conditions so the fan manufacturer can make proper fan and drive selections. In addition, temperature, pressure, and humidity can affect fan components such as the bearings and bearing lubricant. Therefore, the fan manufacturer must know these properties to make proper material selections for the fan components.

Material Moving

Fans that are required to move material such as dust (e.g., sawdust) or other particulate matter require identification and specification of the properties of the air stream. Particulates can be abrasive, require high transport velocities, or be composed of corrosive, explosive chemicals. These materials can affect the fan wheel, casing, shaft, bearings, bearing lubricant, etc., and the fan manufacturer must know these properties to make the proper material selections for the fan components.

Contaminated Air Moving

Fans that are required to move contaminated air (primarily radioactive particles in nuclear facilities) also need to have these properties identified and specified. Radioactive contaminants can affect some of the materials used in fan construction (primarily bearing lubricants) or in ductwork components that are attached to the fan (flexible connections and gaskets). Another primary concern is contaminated leakage into or out of the fan (see Section 5.2.4.3 for information concerning leakage). The fan manufacturer must know the properties of the contaminated air so that proper material selections and leakage provisions can be provided.

5.5 Air Intakes and Stacks

5.5.1 Locating Intakes and Stacks

The design and location of exhaust stacks and air intakes have an important bearing on system performance. If air intakes are too close to the ground, blowing sand, dust, grass clippings, and other particulate matter may be drawn into the building, plugging the supply-air filters and/or reducing their life. Exhaust fumes from vehicles passing nearby or standing close to the building may also be drawn into the building. Intakes must be sited to protect them from snow, ice, and freezing rain during the winter, and baffles or louvers must be provided to give protection from driving rain and to minimize the effect of wind. Architectural louvers should be designed and tested in accordance with AMCA 500-L[43] for pressure drop and water penetration (see Section 5.3.4 for additional information concerning louvers). Wind pressure can have an appreciable effect on flow rates in a low-head ventilation system and can cause pulsations that may disrupt or reverse differential pressure conditions between the zones of the building.

Average wind direction and weather conditions that are likely to cause stack discharges to areas close to the ground (known as looping and